Quantitative Precipitation Estimates Measured by C- and X-Band Radars

The Potential for Integration

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Quantitative Precipitation Estimates Measured by C- and X-band Radars — The Potential for Integration

Introduction

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The perfect weather radar for urban drainage applications is a radar with both long range and high resolution. Unfortunately, in real life a typical trade-off for longer range is a coarser spatial resolution (Einfalt et al., 2004). This is the key motivation for this study. If this trade-off has to be made using a single radar, combining radars with long range and high resolution is an obvious solution.

Weather radars are accounting for both temporal and spatial variability in the precipitation and cover large areas. In the field of urban drainage, these properties provide information for several applications e.g. control and regulation of the storm and wastewater system. When performing precipitation forecasts on radar data, both the range and resolution are important. The length of the forecast is dependent on the radar range and the details on the prediction are dependent of the radar resolution.

In the study, a direct comparison of precipitation data from a long range C-band radar and a high resolution X-band radar is performed. The scope of the study is to investigate the possibilities and potentials for combining the two types of radars.

LAWR X-band

Aau LAWR	X-band (Furono1525)
Frequency	9.41 GHz
Wave length	3.2 cm
Emmision power	25 kW
Temporal resolution	5 min
Spatial resolutions	500 x 500m (range 60km)
Angular resolution	0.95° azimuth
Vertical resolution	± 10°
Data resolution	255 classes
Rotation	24rpm
Scanning elevation	0°

Table 1 Specifications for LAWR (Thorndahl and Rasmussen, 2010)

Sindal C-band

Sindal Radar	C-band
Frequency	5.625 GHz
Wave length	5.4 cm
Emmision power	250 kW
Temporal resolution	10 min
Spatial resolutions	2000 x 2000 m (range 240km)
Angular resolution	1° azimuth
Vertical resolution	± 0.5°
Data resolution	255 classes
Rotation	3.3rpm
Scanning elevation	0.5°, 0.7°, 1.0°, 1.5°, 2.4°,4.5°, 8.5°, 13.0°, 15.0°

Table 2 Specifications for Sindal C-band (Gill et al., 2006)

The Experimental Setup

Fig. 1 Location of the radars. Read dashed square indicate the area of interest. Ranges: 15, 30, 60km for LAWR., 120, 240km for C-band.

For the comparison, an area of the northern part of Denmark is investigated. The area is covered by both a Local Area Weather Radar (LAWR) and a meteorological C-band radar. The area is instrumented with nine tipping bucket rain gauges.

To be able to compare the precipitation measurements from the two radar systems, both radars have been calibrated on the basis of the nine rain gauges for the same period from 1st of June to 27th of July 2009.

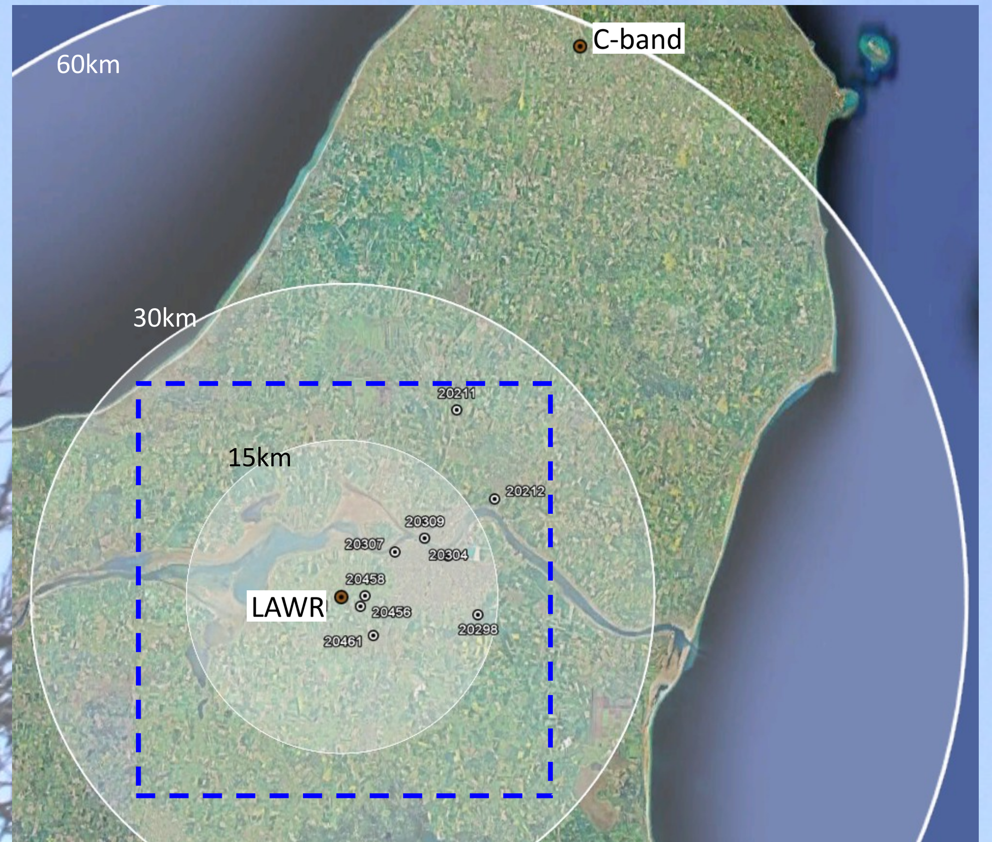

Fig. 2 Close-up of the area with the rain gauges. The blue dashed square indicates the area for spatial correlation.

Spatial Correlation

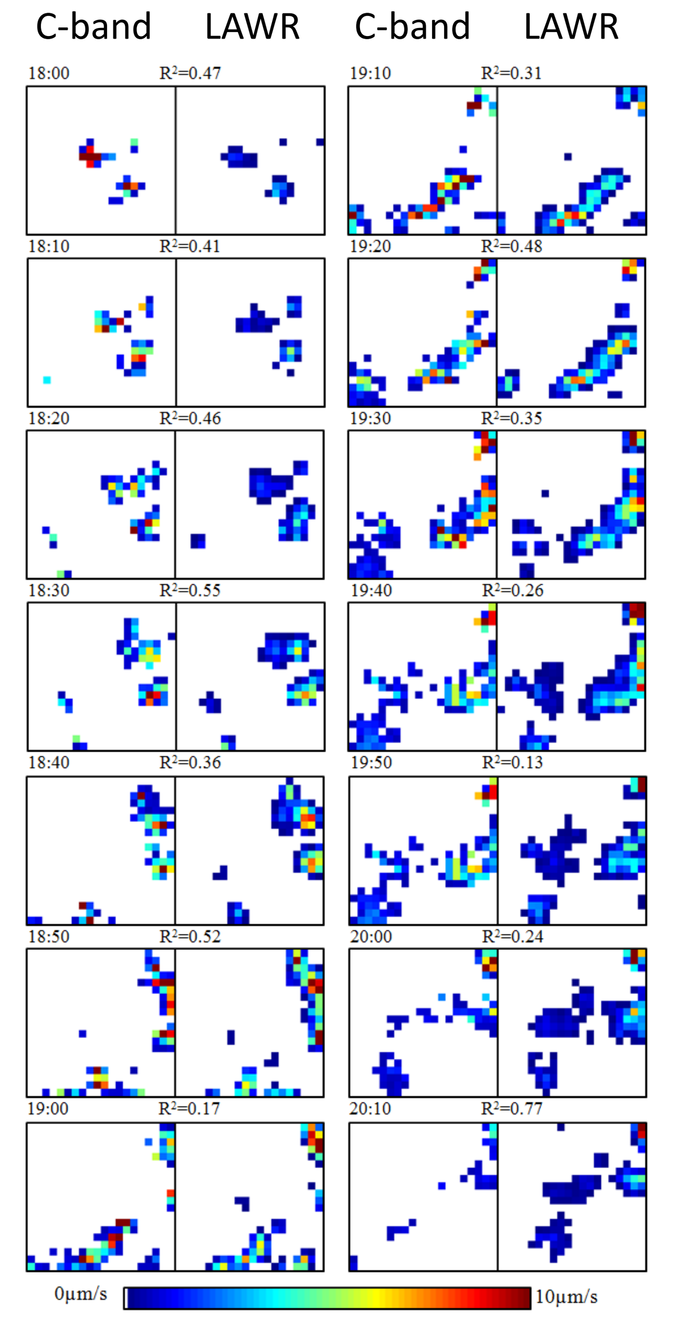

Fig. 3 Corresponding precipitation estimates for C-band and LAWR from 06.07.09. The LAWR is averaged in space to fit the 2x2km resolution of the C-band. The area is a 40x40km square with the LAWR in the center as illustrated in figure 2.

The two radars are working with different temporal and spatial resolution, see table 1 and 2. To be able to quantify the correlation between the two systems, the LAWR data has been averaged in space to fit the 2 x 2 km resolution of the C-band radar. The spatial correlation between the two radar measurements is illustrated in figure 3 for the 6th of July 2009 in the time interval 18:00 to 20:10. The area for comparison is a 40km square with the LAWR located in the center as illustrated in figure 2.

Visually, the images show both similarities and dissimilarities, see figure 3. One explanation for the differences could be the different scanning strategies employed by the two different types of radars. The LAWR is conducting the measurement by a time average with a wide vertical antenna opening angle. The C-band radar is creating a 'snap shot' conducted from several scans in different elevations every 10 minutes.

Despite the differences of the radar systems, the spatial detection of the precipitation by the two systems is relatively similar through the period. At the same time, it is obvious that the images are not identical which is shown by the low correlation coefficients. The similarities of precipitation intensities are somewhat more variable – for some images the highest precipitation intensities are detected in the same locations, while for others it differs.

Strength and Weaknesses

Different meteorological conditions are found to yield different results for the two radar systems. As an example of this, a stradiform and a convective precipitation event are displayed in figure 4. The area for comparison is the full range of the LAWR (see figure 1) and the data shown is the full spatial resolution of both systems.

It is evident that the C-band radar detects a much wider spatial extend of the stratiform precipitation than the LAWR. Due to the large vertical opening angle and the low-laying precipitation, the upper part of the LAWR beam will break out of the precipitation quite close to the radar. This results in only partly filled sampling volumes and thereby poor observations at longer distances.

In the case of convective precipitation, the vertical extent of the precipitation is much higher and partly filled sampling volumes are no issue for the LAWR radar. In this case, the disadvantage of low spatial resolution for the C-band radar becomes clearer. Even though there is a good visual agreement between the radar images, the result also shows that LAWR detects the spatial variations within the convective precipitation in more details.

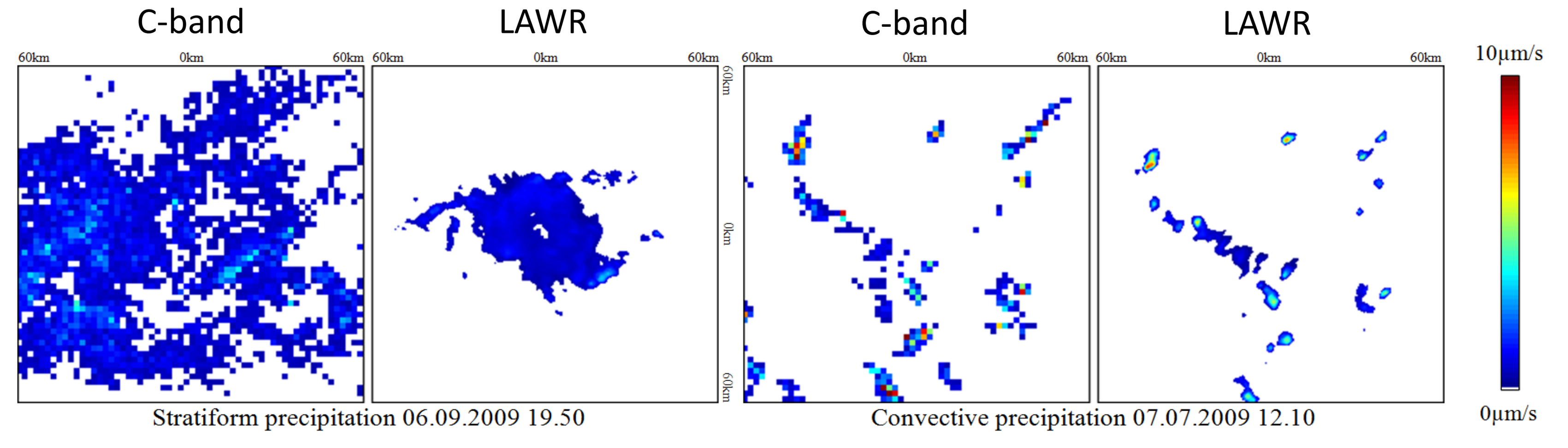

Fig. 4 Two sets of corresponding precipitation estimates form C-band and LAWR. The set to the left is showing a stratiform event. The set to the right is showing a convective event. The compared area is illustrated in figure 1.

Discussion and Conclusion

The purpose of this study was to gain more knowledge about the potential for integration of the two radar systems. As shown, the radars have both strengths and weaknesses associated with their working principle. The radars are supplementing each other quite well and the results demonstrate that a potential for combination of the two radar types is existing. In case of light and wide-spread rain the C-band radar has its strength while the strengths of LAWR are in relation to the convective rainfall.

For the future integration of the measurements, it will be necessary to consider the meteorological conditions of the precipitation as this affects the performance of the radar systems. The differences in antenna design and target distance mean that elevation and the width of the radar bean will be different. Therefore, the vertical profile of the precipitation will also play an important role for the future combination of the radar measurements.

It is important to point out that the differences are just as important as the similarities, because it is within the differences the possible improvements are hidden, while it is the similarities that makes the integration possible.

Acknowledgment

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